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Title
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Permalink
https://escholarship.org/uc/item/02r486pv

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 28(28)

ISSN
1069-7977

Authors
Dieussaert, Kristien
Vansteenwegen, Debora
Assche, An Van

Publication Date
2006

Peer reviewed

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The Context Sensitivity of Experience based Learning in Belief Revision

Kristien Dieussaert (kristien.dieussaert@psy.kuleuven.be)
Debora Vansteenwegen (deb.vansteenwegen@psy.kuleuven.be)
An Van Assche (an.vanassche@student.kuleuven.be)
University of Leuven, Department of Psychology,
102 Tiensestraat, B-3000 Leuven, Belgium

Abstract

In this paper we show that experience based beliefs are more context sensitive than instruction based beliefs. The adaptation to a new context happens faster and is more extensive with experience based beliefs. Moreover we will demonstrate that experience based learning is able to overrule what is learned by instructions.

KEYWORDS: BELIEF REVISION, CONTEXT

Introduction

This research relates two subdomains of cognitive psychology with an interest in belief revision that have been studied completely separately in the past. On the one hand, we rely on the reasoning literature regarding belief revision (For a review, see Dieussaert & Schaeken, 2005). On the other hand, we rely on the contingency learning literature regarding belief revision (For a review, see De Houwer & Beckers, 2002).

Both research domains have adopted a different strategy to study belief revision. In reasoning research (e.g., Elio & Pelletier, 1997), participants (pps) are given a conditional statement (if p, then q; e.g., if that bacteria is present in your blood, then you have the Okro disease) and a categorical statement (p; e.g., the bacteria is present), and are asked to deduce the conclusion, or are given the conclusion (q; e.g., you have the Okro disease) [*belief construction phase*]. Next, new information that contradicts the conclusion is presented (not-q; e.g., you do not have the Okro disease) [*belief revision phase*] and pps. are asked to revise one of the former statements in order to regain a consistent belief set [*test phase*].

In most human contingency learning experiments (e.g., Catena *et al.,* 2002), pps. receive information about a number of situations in which certain Cues (C) and Outcomes (O) are either present or absent, and they are asked to judge the extent to which the presence of a C is related to the presence of O. Three phases are discerned: first, a contingency is acquired [*belief construction phase*], next it is extinguished [*belief revision phase*]. The resulting 'degree of belief' in the C-O contingency is tested in the third phase [*test phase*]. Additional manipulations of, for example, the acquisition and extinction context influence the resulting degree of belief in the contingency.

These differences in paradigm reflect a different view on how beliefs are constructed: through instruction (if C, then O) or through experience (several C-O trials). We consider both forms of belief construction important since in daily life, people construct their beliefs in various ways, depending on the situation. Some beliefs are constructed through communication (e.g., If you run out of brake oil, your brake will not work) while others are constructed through experience (e.g., If you eat, you won't be hungry any more). That experiences of the latter kind easily fit into an 'if-then' formulation has been shown before in Dieussaert *et al.* (2001).

The predictions and outcomes of the studies in both research domains are opposite. In reasoning research, the main finding is that pps. revise their belief in the conditional rule in favor of their belief in the categorical statement (e.g., for an explanation in terms of mental models, see Johnson-Laird *et al.,* 2004). In contingency learning research, the main finding is that when a change in context is introduced, the primary belief in the C-O contingency becomes visible again in the 3rd phase after being extinguished in the 2nd phase (e.g., Garcia-Gutierrez & Rosas, 2003). The latter phenomenon is called 'renewal' (e.g., Bouton, 1993).

In a previous study (Dieussaert *et al.,* 2005), we were able to reconciliate both outcomes. We demonstrated that beliefs induced by instruction, as applied in reasoning research, were not sensitive to renewal, while beliefs induced by experience, as applied in contingency research, clearly showed a renewal effect. We showed this by comparing beliefs acquired through instruction vs. beliefs acquired through experience [*belief construction phase*]. The contradictive experience based information was presented in the same context (AAA) or in a different context (ABA) than the acquisition context. Renewal only took place when the contexts had been changed during the experiment and when the belief was induced through experience.

Two explanations were proposed for this effect: "These findings can be interpreted in various ways. On the one hand, one could argue that beliefs acquired through instruction are less stable and more susceptible to negative experiences than beliefs acquired through experience. On the other hand, one could also state that instruction based beliefs are less context sensitive than experience based beliefs since no difference between the AAA and ABA level is observed." (Dieussaert *et al.,* 2005, p. 599).

In this paper, we sort out which of the two explanations holds. In Experiment 1, we manipulate the context again, but instead of giving the contradictive information through experience, we will present it in an instruction format [*belief revision phase*]. This will allow us to show that instruction

based beliefs are not merely more susceptible to negative experiences, but that they really are less context sensitive than experience based beliefs. In Experiment 2, we will combine instructions and experiences in the belief construction phase (Experiment 2b) as well as in the belief revision phase (Experiment 2a). This will provide us with convergent evidence that the context sensitivity of experience based beliefs is able to overrule the context insensitivity of instruction based beliefs.

Experiment 1

Method

Participants

One hundred nineteen pps. took part in the experiment. Seventy one first grade students at the University of Leuven took part as a partial fulfilment of a course requirement and 48 high school students (age: ± 18) took part on a voluntary basis. They were randomly assigned to the different groups.

Design

The within-subjects independent variable Phase consists of three levels: belief construction, belief revision and test. A judgment is given at each trial, followed by feedback. In the belief construction phase, a C (present bacteria Verde) – O (Okro disease) relation is taught through experience or instruction. For half of the pps., this phase consists of 10 trials with the following course: three experience trials (C – O), one test trial (C – no information), two experience trials (C – O), one test trial (C – no information), two experience trials (C-O) and one test trial (C – no information). For the other half of the pps. the belief construction phase consists of the instruction that the statement 'If the bacteria Verde is present, the patient has the Okro disease' holds and one test trial (C - no information).

belief construction	belief revision	test
Instruction	Instruction	
Context A (1 trial)	Context A (1 trial)	Context A (1 trial)
Context A (1 trial)	Context B (1 trial)	Context A (1 trial)
Experience	Instruction	
Context A (10 trials)	Context A (1 trial)	Context A (1 trial)
Context A (10 trials)	Context B (1 trial)	Context A (1 trial)

Figure 1: Course of four levels in Experiment 1.

In the belief revision phase, pps. are instructed that the O (Okro disease) does not follow from the C (bacteria Verde): 'If the bacteria Verde is present, the patient does not have the Okro disease'. This phase also consists of one test trial (C- no information). In the test phase (1 test trial), the C-O relation is tested (C- no information available).

The between-subjects independent variables are Belief Construction Mode (BCM; explained above) and Context. The belief revision phase is set in the same (Context A) or another (Context B) context than the belief construction phase. More specifically, the hospitals from which the patient filing cards are taken is manipulated. See Figure 1 for a visualisation of the design.

Material and Procedure

Pps. were instructed in written form. They were asked to imagine being a researcher in a medical research institute, who collected the filing cards of a lot of patients.

A computer program was developped with 'AFFECT'[1] software. It was run on standard PCs. Pps. were shown jpeg-figures containing a patient filing card with the following information:

- the name of the hospital (in a particular color for each hospital)
- the result of a test on the presence of the yellow bacteria 'Amarillo'
- the result of a test on the presence of the green bacteria 'Verde'
- the result of a test on the presence of the pink bacteria 'Rosa'

If the result is positive, the bacteria are present. If the result is negative, the bacteria are absent. All figures were equal: the bacterias Amarillo and Rosa being always absent, the bacteria Verde being always present.

It is the participant's task to find out whether one of these bacteria causes a newly discovered disease, 'the Okro disease'.

The pps. of the 'BCM: Experience group' received several experience and test trials. They saw a filing card until they marked the extent to which they believed a patient has the disease on a seven point scale. On the scale, 1 indicates 'certain the patient does not have the Okro disease' and 7 indicates 'certain the patient has the Okro disease'; 4 indicates 'the patient may or may not have the disease'. Once the participant had given the answer, (s)he received feedback on the condition of the patient. In the experience trials the feedback was 'The patient has the Okro disease'. In the test trials the feedback was 'No information available! It is unknown whether the patient has the Okro disease or not.'

The pps. of the 'BCM: Instruction group' received the same filing card, with the following writing below: From previous study of the filing cards, you know that if the bacteria Verde is present, the patient has the Okro disease. Afterwards, they were given one test trial.

In the belief revision phase, all pps. received an instruction filing card followed by one test trial. Below the filing card, the following was written: From previous study of the filing cards, you know that if the bacteria Verde is present, the patient does not have the Okro disease.

[1] Hermans, D., Clarysse, J., Baeyens, F., & Spruyt, A. (2002). *Affect (Version 3.0)* [Computer software; retrieved from http://www.psy.kuleuven.ac.be/leerpsy/affect]. University of Leuven, Belgium.

The context of the belief revision phase was manipulated. For half of the pps., the hospital setting of the filing cards was the same (AAA level), for the other half it differed (ABA level) from the hospital setting in the belief construction phase.

At the end of the experiment, all pps. were asked if they noticed a context change during the experiment. This question was added to make sure that only pps. who actually noticed the context-change for ABA were included in the analysis. The participant's awareness of the context change is a minimal requirement for him or her to take context into account in determining the belief state.

Pps. were invited to ask questions if anything was not clear to them. During the experiment, no questions were allowed. Once the pps. started, they worked through the course of the experiment in a self paced manner.

Results

Table 1: The mean score [SD] on the last test trial of the belief construction, revision and test phase on a [1; 7] scale.

Ctxt	**belief construction**	**belief revision**	**test**
	Instruction	Instruction	
AAA	6.14 [0.35]	2.10 [0.51]	3.57 [0.46]
ABA	5.70 [0.34]	2.35 [0.48]	3.74 [0.44]
	Experience	Instruction	
AAA	6.16 [0.32]	3.08 [0.46]	2.72 [0.42]
ABA	5.13 [0.33]	2.00 [0.47]	2.58 [0.34]

Twenty six out of the 119 pps. did not answer the context question at the end of the experiment, or gave a wrong answer. They were discarded from further analysis. Thus, 21 pps. from the AAA-Instruction, 25 from the AAA-Experience, 23 from the ABA-Instruction and 24 from the ABA-Experience group were included in the analysis. Table 1 shows an overview of the results.

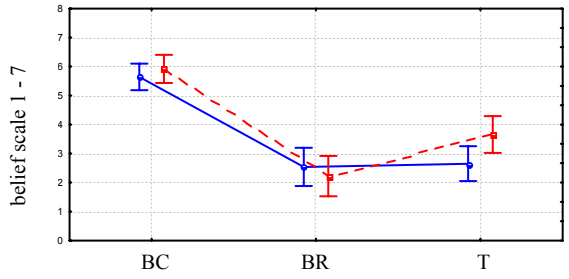

Figure 2: Graph of interaction between the three phases and the two BCM (Ins and Exp) of Experiment 1.
The full line indicates the course of the Experience-Instruction group. The dotted line indicates the course of the Instruction-Instruction group.

An ANOVA shows a main effect of Phase ($F(2,178) = 91.60$, $p < .0001$), but no significant main effect of Belief Construction Mode (BCM) or Context. A significant interaction between Phase and BCM is observed: $F(2,178) = 3.16$, $p < .05$. This interaction is illustrated in Figure 2.

A planned comparison reveals that the interaction is even more significant when we compare the last two phases (revision and test): $F(1,89) = 7.53$, $p < .01$.

Discussion

This experiment was set up as a follow up of a previous series of experiments, in which we showed that instruction based learning resulted in less renewal than experience based learning. Two explanations for this effect were proposed (see Dieussaert *et al.,* 2005): 1) instruction induced belief is stable and more susceptible to negative information or 2) instruction induced belief is less context sensitive.

This experiment clearly provides evidence in favor of the second explanation. Instruction induced belief does not seem to be more susceptible to negative information, since renewal takes place in the instruction-instruction groups. Instruction based beliefs seem to be very context insensitive, since no main effect of Context could be observed.

In Experiment 2a and 2b, we will go a step further in the search to the power of instruction based versus experience based beliefs. We will provide more evidence for the context sensitivity of experience based beliefs, and we will show that no more than a single experience is able to overrule the context insensitivity of instruction based beliefs.

Experiment 2a

Method

Participants

One hundred twenty pps. took part in the experiment. All were students at the University of Leuven and took part on a voluntary basis (age: 18-24) They were randomly assigned to the different groups.

Design

The within-subjects independent variable Phase consists of three levels: belief construction, belief revision and test. A judgment is given at each trial, followed by feedback. In the belief construction phase, a C (present bacteria Verde) – O (Okro disease) relation is taught through experience or instruction. For half of the pps., this phase consists of 10 trials with the following course: three experience trials (C – O), one test trial (C – no information), two experience trials (C – O), one test trial (C – no information), two experience trials (C-O) and one test trial (C – no information). For the other half of the pps. the belief construction phase consists of the instruction that the statement 'If the bacteria Verde is present, the patient has the Okro disease' holds and one test trial (C - no information).

In the belief revision phase, pps. experienced that the O (Okro disease) does not follow from the C (bacteria Verde) in 10 trials with the following course: three experience trials (C – notO), one test trial (C – no information), two experience trials (C – notO), one test trial (C – no information), two experience trials (C - notO) and one test trial (C – no information). Half of the pps. additionally received the following statement at the beginning of the belief revision

phase: 'If the bacteria Verde is present, the patient does not have the Okro disease'. In the test phase (1 test trial), the C-O relation is tested (C- no information available).

belief construction	**belief revision**	**test**
Context A	Context B	Context A
Instruction (1 trial)	Experience (10 trials)	(1 trial)
Instruction (1 trial)	Instruction+Experience (10 trials)	(1 trial)
Experience (10 trials)	Experience (10 trials)	(1 trial)
Experience (10 trials)	Instruction+Experience (10 trials)	(1 trial)

Figure 3: Course of four levels in Experiment 2a.

The between-subjects independent variables are Belief Construction Mode (BCM) and Belief Revision Mode (BRM). The belief revision phase is set in another (Context B) context than the belief construction phase and test phase (Context A). More specifically, the hospitals from which the patient filing cards are taken is manipulated. See Figure 3 for a visualisation of the design.

Material and Procedure

See Experiment 1.

The pps. of the BRM: Experience group received only experience trials. The pps. of the BRM: Instruction+Experience (InsExp) group received an instruction filing card before they received the experience trials.

Results

Table 2: The mean score [SD] on the last test trial of the acquisition, extinction and test phase on a [1; 7] scale.

Mode	**belief construction**	**belief revision**	**Test**
	Context A	Context B	Context A
Instruction			
Exp	5.95 [0.30]	3.00 [0.32]	4.13 [0.51]
Ins-Exp	5.93 [0.28]	1.52 [0.29]	4.26 [0.46]
Experience			
Exp	5.93 [0.27]	1.86 [0.28]	5.07 [0.44]
Ins-Exp	6.08 [0.28]	1.77 [0.29]	3.73 [0.47]

Sixteen out of the 120 pps. did not answer the context question at the end of the experiment, or gave a wrong answer. They were discarded from further analysis. Thus, 22 pps. from the Instruction-Experience, 29 from the Experience-Experience, 27 from the Instruction-InsExp and 26 from the Experience-InsExp group were included in the analysis. Table 2 shows an overview of the results.

An ANOVA shows a main effect of Phase ($F(2,200) = 152.13$, $p < .0001$), but no significant main effect of Belief Construction Mode (BCM: Ins vs Exp) or Belief Revision Mode (BRM: Exp vs InsExp). No significant two-way interactions are observed. A significant three-way interaction is however observed: $F(2,200) = 4.00$, $p < .01$. This interaction is illustrated in Figure 4.

The most eye catching difference stems from the belief revision phase. At that point, a significant interaction between the BCM and BRM is observed: $F(1,100)=5.62$, $p < .05$. Where the BCM Exp and Ins clearly differ in the BRM group: Exp ($F(1,100) =7.34$, $p < .01$), the difference has faded in the BRM group InsExp. The revision level here equals the revision level of the BCM-Experience group.

A planned comparison shows for each group a clear increase in the belief in the test phase at $p < .0001$ (exception: $p < .05$ for Instruction – Experience due to the high level in the belief revision phase).

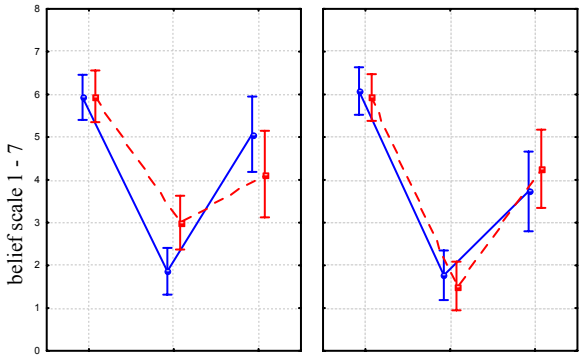

Figure 4: Graph of three-way interaction of Experiment 2a. The left side of the figure reflects the results of the BRM: Exp group, the right side reflects the results of the BRM: InsExp group. The full line indicates the course of the BCM: Exp group. The dotted line indicates the course of the BCM: Ins group.

Discussion

In this experiment we investigated whether the context stability of an instruction is able to overrule the context sensitivity of an experience, or vice versa.

We operationalised this question by manipulating the BRM. Half of the pps. received a (negative) instruction additional to the experience trials in the BRM.

The results confirm the context stability of instruction vs. experience in the common set up. After 10 negative experience trials in the belief revision phase, the belief in the C-O contingency stays higher when the C-O contingency was adopted by instruction than when it was adopted by experience. However, this context stability fades away when an instruction is added in the belief revision phase. The belief in the C-O contingency is at an equal low level for the belief construction through instruction as through experience.

The crucial indication that the context sensitivity of experiences overrules the context stability of instruction lies in the test phase: when returning to the original hospital context A, the belief in the C-O contingency increases again. If the negative instruction in the belief revision phase would

have overruled the context sensitive experiences, no renewal would have appeared.

In the following experiment, we will tackle the same question, but operationalised by manipulating the BCM.

Experiment 2b

Method

Participants

Ninety eight new pps. took part in the experiment. Sixty pps. from Experiment 2a were also included in this experiment to provide comparison data. All were students at the University of Leuven and took part on a voluntary basis (age: 18-24) They were randomly assigned to the different groups.

Design

The within-subjects independent variable Phase consists of three levels: belief construction, belief revision and test. A judgment is given at each trial, followed by feedback. . In the belief construction phase, a C (present bacteria Verde) – O (Okro disease) relation is taught through instruction or instruction and one experience. For one part of the pps., this phase consists of the instruction that the statement 'If the bacteria Verde is present, the patient has the Okro disease' holds and one test trial (C - no information). For the other part, it consists of the instruction, one experience trial (C – O follows) and one test trial (C – no information).

belief construction	belief revision	test
Context A	Context B	Context A
Instruction (1 trial)	Experience (10 trials)	(1 trial)
Instruction (1 trial)	Instruction+Experience (10 trials)	(1 trial)
Instruction+Experience (2 trials)	Experience (10 trials)	(1 trial)
Instruction+Experience (10 trials)	Instruction+Experience (10 trials)	(1 trial)

Figure 5: Course of four levels in Experiment 2b.

In the belief revision phase, pps. experienced that the O (Okro disease) does not follow from the C (bacteria Verde) in 10 trials with the following course: three experience trials (C – notO), one test trial (C – no information), two experience trials (C – notO), one test trial (C – no information), two experience trials (C - notO) and one test trial (C – no information). Part of the pps. additionaly received the following statement at the beginning of the belief revision phase: 'If the bacteria Verde is present, the patient does not have the Okro disease'. In the test phase (1 test trial), the C-O relation is tested (C- no information available).

The between-subjects independent variables are Belief Construction Mode (BCM) and Belief Revision Mode (BRM). The belief revision phase is set in another context (Context B) than the belief construction phase and test phase (Context A). More specifically, the hospitals from which the patient filing cards are taken is manipulated. See Figure 5 for a visualisation of the design.

Material and Procedure

See Experiment 2a.

The pps. of the 'BCM: Instruction group' received only an instruction. The pps. of the 'BCM: Instruction+Experience (InsX) group' received an instruction plus one additional experience trial.

Results

Twenty-four out of the 158 pps. did not answer on the context question at the end of the experiment, or gave a wrong answer. They were discarded from further analysis. Thus, 22 pps. from the Instruction-Experience, 44 from the InsX-Experience, 27 from the Instruction-InsExp and 41 from the InsX-InsExp group were included in the analysis. Table 3 shows an overview of the results.

Table 3: The mean score [SD] on the last test trial of the acquisition, extinction and test phase on a [1; 7] scale.

Mode	belief construction	belief revision	Test
	Context A	Context B	Context A
Instruction			
Exp	5.95 [0.30]	3.00 [0.32]	4.13 [0.51]
Ins-Exp	5.93 [0.28]	1.52 [0.29]	4.26 [0.46]
InstructionX			
Exp	6.32 [0.20]	1.98 [0.22]	4.89 [0.35]
Ins-Exp	6.37 [0.21]	1.51 [0.23]	4.17 [0.37]

An ANOVA shows a main effect of Phase ($F(2,260) = 203.94$, $p < .0001$), but no significant main effect of Belief Construction Mode (BCM: Ins vs InsX) or Belief Revision Mode (BRM: Exp vs InsExp, $p = .05$). A significant two way interaction is observed between Phase and BCM: $F(2,260) = 3.07$, $p < .05$. The interaction between Phase and BRM nearly reaches significance: $F(2,260) = 2.99$, $p = .05$. No significant three-way interaction is observed ($p = .08$). This interaction is illustrated in Figure 6.

The left side of the figure are the data discussed in Experiment 2a: Instructions loose context stability when an instruction is added in the BRM phase. More striking is that the instruction also looses context stability when one experience trial is added to the instruction in the BCM phase (right side of the figure).

A planned comparison shows a difference between the BCM groups (Ins vs InsX) at the belief revision phase for the BRM: Exp group ($F(1,130) = 6.97$, $p < .01$).

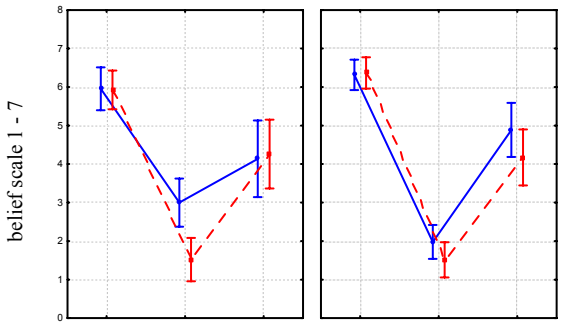

Figure 6: Graph of groups of Experiment 2b.
The left side of the figure reflects the results of the BCM: Ins group, the right side reflects the results of the BCM: InsX group. The full line indicates the course of the BRM: Exp group. The dotted line indicates the course of the BCM: InsExp group.

Discussion

In Experiment 2a, we gathered indications that the context stability of an instruction is overruled by the context sensitivity of an experience. In Experiment 2b, we aimed at finding converging evidence for this observation through a different operationalisation. We manipulated the BCM. Part of the pps. received a single experience additional to the instruction in the BCM.

The crucial indication that the context sensitivity of experiences overrules the context stability of instruction lies in the belief revision phase: adding a single experience to the instruction results in a decrease at that level. This means that the additional experience is able to make the belief more context sensitive.

General discussion

In this research we bring together two separately developped lines of research, reasoning and human contingency research, on the same topic: belief revision. In a previous paper (Dieussaert *et al*., 2005) , we showed that the opposite predictions of both research lines with respect to the final belief state can be reconciliated by taking the methodology for belief construction into account. We showed that the final belief state of beliefs induced by instruction is significantly lower than the final belief state of beliefs induced by experience. This is exactly in line with the findings in reasoning research: the final belief in the instructed conditional statement lowers significantly after contradictive information is presented (e.g., Politzer & Carles, 2001). It is also exactly in line with the findings in contingency research: the final belief in experienced C-O contingencies is not affected by contradictive information presented in another context (e.g., Vadillo *et al.,* 2001).

In this paper, we provided an explanation for these findings: experience based beliefs are far more adaptive to context changes than instruction based beliefs, which are rather context insensitive. We also demonstrated that when instructions and experience are presented together, the context sensitivity of the experience based beliefs is able to overrule the context insensitivity of the instruction based beliefs.

These theoretical findings have considerable implications for both the reasoning research as well as the contingency research. They should both be aware of the restrictiveness of their findings due to the experimental paradigm they apply.

Acknowledgments

This research is carried out with the financial support of the National Council for Scientific Research – Flanders, Belgium (FWO grant G.0320.05 for Kristien Dieussaert and FWO postdoctoral research grant for Debora Vansteenwegen).

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